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NATIONAL DAM INSPECTION PROGRAM. LAKE CHILLISQUAQUE (NDS ID NUM--ETC(U)
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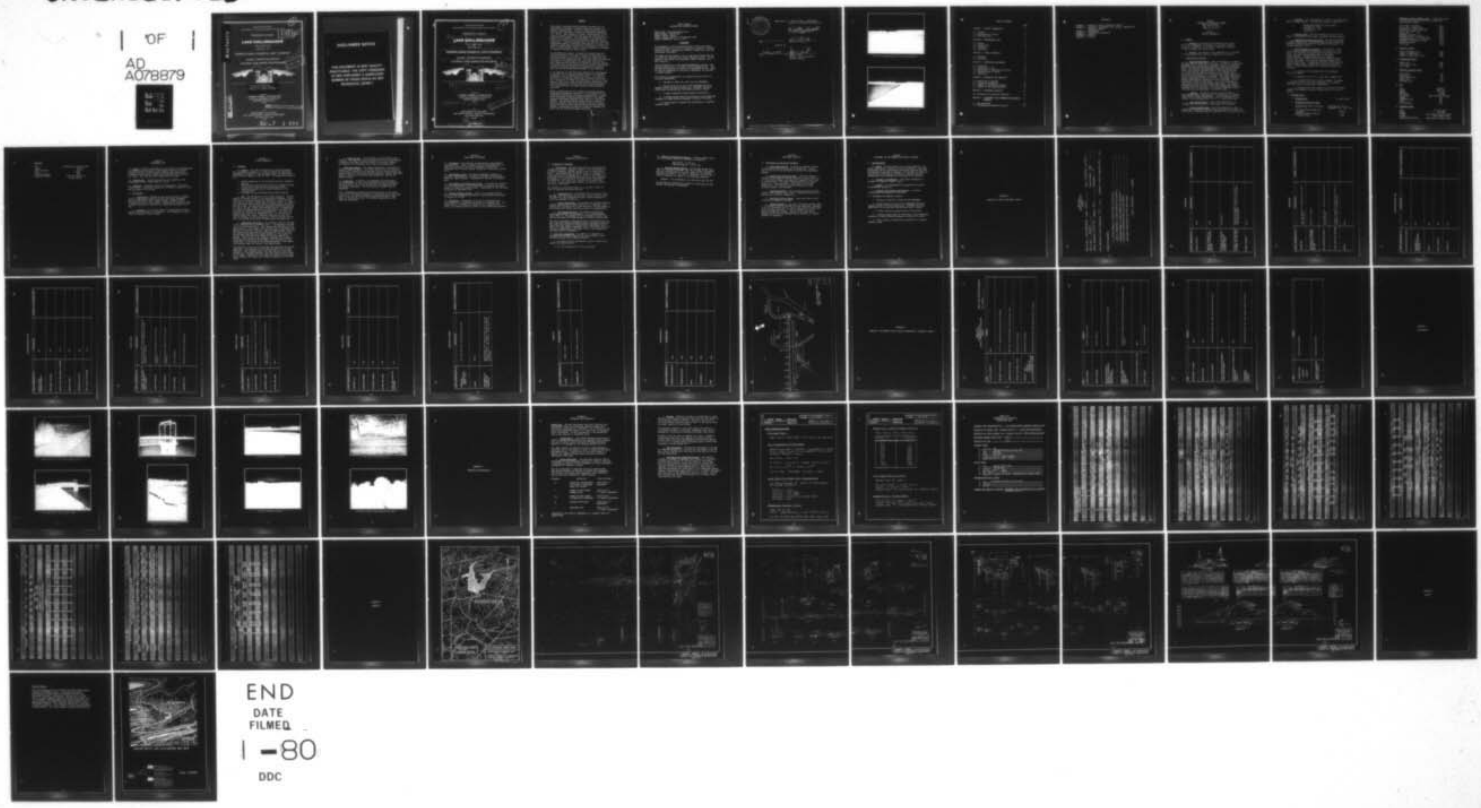

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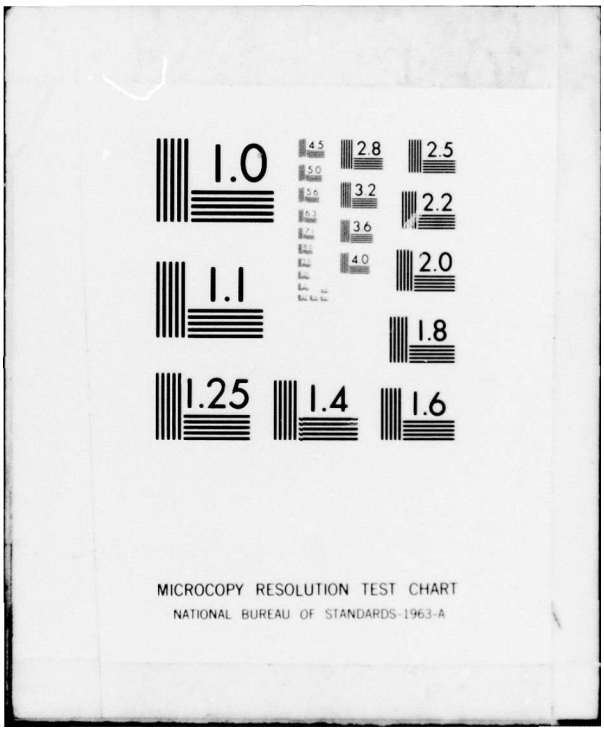
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SUSQUEHANNA RIVER BASIN

MIDDLE BRANCH OF CHILLISQUAQUE CREEK, MONTOUR COUNTY

PENNSYLVANIA

LEVEL II

LAKE CHILLISQUAQUE

NDS ID NO. PA-815

DER ID NO. 47-8

PENNSYLVANIA POWER & LIGHT COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

Prepared By

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG, PENNSYLVANIA
15931

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DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

AUGUST, 1979

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SUSQUEHANNA RIVER BASIN

MIDDLE BRANCH OF CHILLISQUAQUE CREEK, MONTOUR COUNTY

PENNSYLVANIA

(6) National Dam Inspection Program.

LAKE CHILLISQUAQUE

(NDS ID ~~NO.~~ Number PA-815

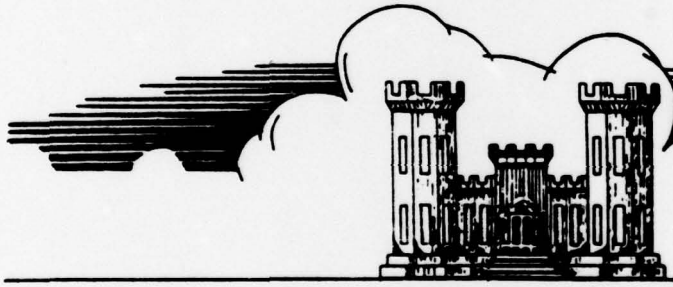
DER ID ~~NO.~~ Number 47-8), Susquehanna River Basin,

Middle Branch of Chillisquaque Creek, Montour County,

PENNSYLVANIA POWER & LIGHT COMPANY

PHASE I INSPECTION REPORT, (Pennsylvania)

NATIONAL DAM INSPECTION PROGRAM



(10) R. Jeffrey / Kimball
Kuang Hwei / Chuang

(12) 69

Prepared By

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG, PENNSYLVANIA
15931

(15) DACW31-79-C-0009

FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

(11) AUGUST, 1979

411 059

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION REPORT

NAME OF DAM: Lake Chillisquaque Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Montour
STREAM: Middle Branch of Chillisquaque Creek
DATE OF INSPECTION: May 23, 1979

ASSESSMENT

The assessment of Lake Chillisquaque Dam is based upon visual observations made at the time of inspection, review of available records and data, hydrology and hydraulic computations, and past operational performance.

The inspection and review of data of Lake Chillisquaque Dam did not reveal any problems which require emergency action. The dam appears to be stable, well maintained, safely operated and in good condition.

Lake Chillisquaque is a high hazard-intermediate size dam. The spillway design flood is the PMF (Probable Maximum Flood). The spillway and reservoir are capable of controlling the PMF. Based on criteria established by the Corps of Engineers, the spillway is termed adequate.

The following recommendations and remedial measures should be instituted immediately.

1. Continue to remove all trees from the embankment.

2. The wet areas at the toe of the embankment should be examined during the routine inspections. Drainage from these areas should be provided and flow monitored when it exists.

3. A formal inspection program should be instituted.

4. A warning system should be instituted to warn downstream residents of large spillway discharges or failure of the dam.

5. Valves should be operated and lubricated on a regularly scheduled basis.

SUBMITTED BY: L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS AND ARCHITECTS

R Jeffrey Kimball
R. Jeffrey Kimball, P.E.

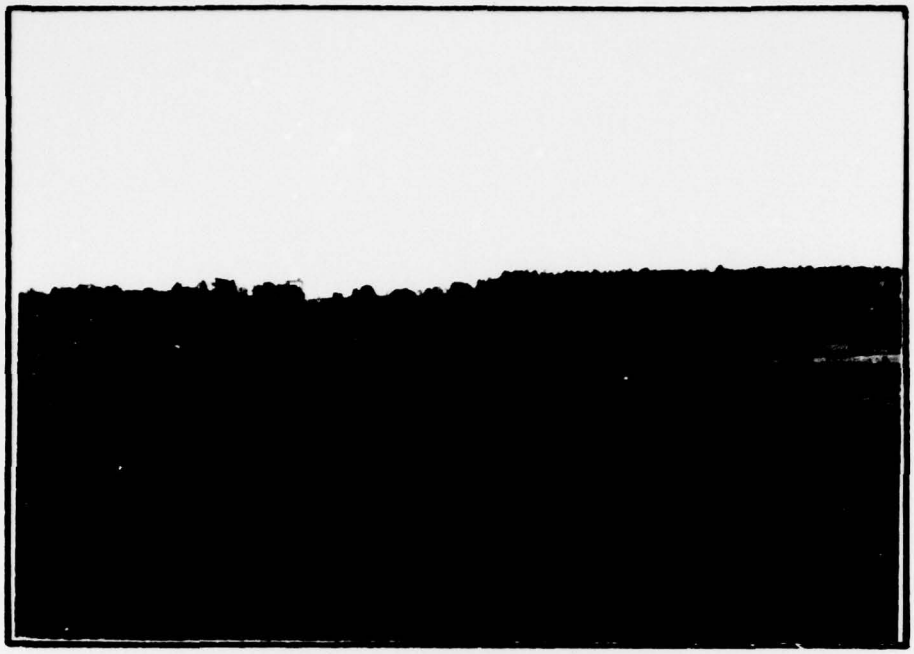
Date

K. Chuang
Kuang Hwei Chuang, P.E.

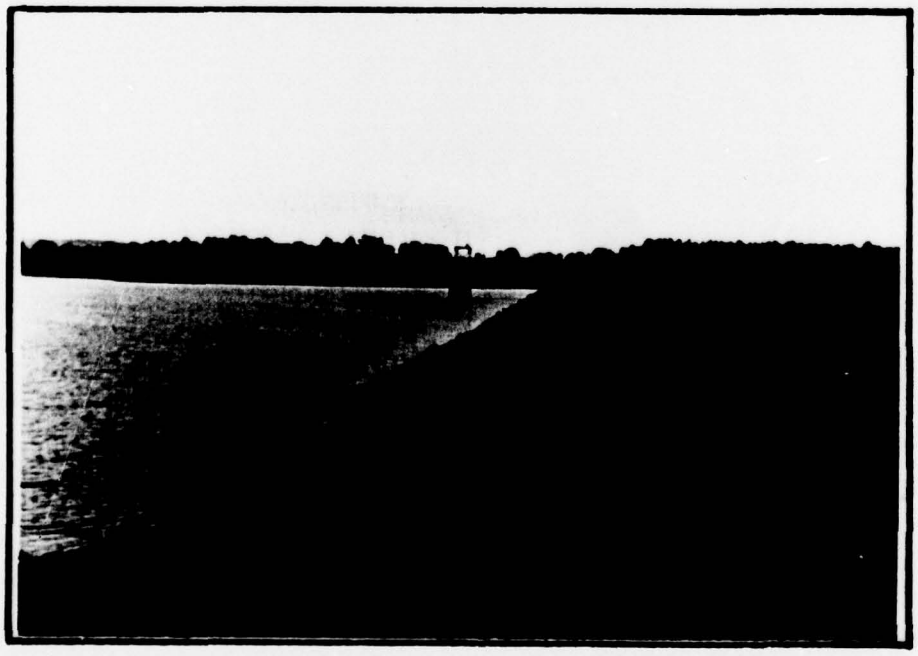
APPROVED BY:

16 August 1979
Date

James W. Peck
JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



Overview of downstream slope from right abutment.



Overview of upstream slope and crest from right abutment.

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APPENDICES

PHASE I
NATIONAL DAM INSPECTION PROGRAM
LAKE CHILLISQUAQUE
NDI I.D. NO. PA 815
DER I.D. NO. 47-8

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Lake Chillisquaque is an earth-fill dam 2000 feet long and 54 feet high. The dam is a zoned earth embankment with a center core consisting of silty clay material and the upstream and downstream portions consisting of weathered shale. The upstream and downstream slopes were constructed at 2.5H:1V with berms at elevation 582.0. The crest of the dam is 12 feet wide and forms an access road at elevation 605.5. The outlet works consist of a concrete control tower connected to two 36" steel pipes encased in concrete. The outlet works has a positive upstream shut off in the form of a bulkhead. The flow through these pipes is regulated by a 36" sluice gate, an 18" cone valve or an 8" by pass valve. At the toe of the dam is a valve house to control flow through these pipes. The earthen emergency spillway is located on the left abutment and contains a concrete sill 750 feet long. The spillway discharge channel is 1300 feet long and discharges to a natural stream.

b. Location. The dam is located on Middle Branch of Chillisquaque Creek, approximately 1.7 miles north of Strawberry Ridge, Montour County Pennsylvania. Lake Chillisquaque can be located on the Washingtonville U.S.G.S. 7.5 minute quadrangle.

c. Size Classification. Lake Chillisquaque Dam is an indermediate size structure (54 feet high, 4400 acre-feet).

d. Hazard Classification. Lake Chillisquaque is a high hazard dam. Downstream conditions indicate that loss of more than a few lives is probable should the structure fail. (See section 3.1e).

e. Ownership. Lake Chillisquaque is owned by the Pennsylvania Power and Light Company. Correspondence should be addressed to:

Pennsylvania Power and Light Company
901 Hamilton Street
Allentown, PA 18101
215-821-5151

f. Purpose of Dam. Lake Chillisquaque is used for water supply for the Montour Power Plant, recreation and flood control.

g. Design and Construction History. The dam was designed by Ebasco Services Inc. The dam was constructed by Vipond and Vipond with Ebasco performing the construction inspection. The dam was completed in 1971.

h. Normal Operating Procedures. The reservoir is used for storage of emergency cooling water for the Montour Power Plant. In addition to normal inflow, the reservoir has a 48" supply line from the Susquehanna River to add water to the reservoir. Normal operation of the reservoir requires that the 8" bypass line be open to pass the minimum flow to the stream. All valves are operated automatically from the power plant. In addition, the valves can be operated manually from the dam. Normal water level is at elevation 594.0. During flooding periods the following procedures are utilized:

1. At elevation 596 the pumps from the Susquehanna River are stopped.

2. At elevation 597 the 8" by pass line is opened full.

3. At elevation 598 the 18" valve is opened. The amount of opening of the 18" valve may be limited by plant makeup water and critical cooling water requirements.

4. At elevation 598.5 the curator of the Montour Preserve inspects the emergency overflow to assure that it is clear of debris.

1.3 Pertinent Data.

a. Drainage Area. 5.6 square miles

b. Discharge at Dam Site (cfs).

Maximum known flood at dam site	Approximately 4500 cfs September, 1975, elev. 601.6
36" drain line at normal pool elevation	Unknown
Emergency spillway capacity at top of dam	29022

c. Elevation (U.S.G.S Datum) (feet). - Elevations worked from spillway crest elevation 600 obtained from construction drawings.

Top of dam - low point	605.5
Top of dam - design height	605.0
Maximum pool - design surcharge	604.5
Full flood control pool	600.0
Normal pool	594.0
Emergency spillway crest	600.0
Upstream portal - 36" drain line	552.5
Downstream portal - 36" drain line	551.4
Streambed at centerline of dam	551.4
Maximum tailwater	None
Toe of dam	551.4

d. Reservoir (feet).

Length of maximum pool	6000
Length of normal pool	5000
Length of flood control pool	5500

e. Storage (acre-feet).

Normal pool	2200
Flood control pool	3300
Top of dam	4400

f. Reservoir Surface (acres).

Top of dam	220
Maximum pool	220
Flood control pool	167
Normal pool	113
Spillway crest	167

g. Dam.

Type	Earthfill
Length	2000 feet
Height	54 feet
Top width	12 feet
Side slopes	Both 2.5H:1V with berms
Zoning	Yes
Impervious core	Yes
Cutoff	Yes
Grout curtain	Yes

h. Reservoir Drain.

Type	36" steel pipe
Length	220 feet
Closure	Sluice gate in control tower
Access	From control tower
Regulating facilities	Sluice gate in control tower

i. Spillway.

Type	Uncontrolled concrete sill
Length	750 feet
Crest elevation	600.0
Gates	None
Upstream channel	Lake
Downstream channel	1300 foot long cut in natural ground

SECTION 2
ENGINEERING DATA

2.1 Design. Review of information in the files of the Commonwealth of Pennsylvania, Department of Environmental Resources and the Pennsylvania Power & Light Company revealed that construction drawings, design reports, permits and photographs were available for review. All this data was reviewed for this study.

2.2 Construction. Construction reports are available at the Pennsylvania Power & Light Company's office.

2.3 Operation. Operating records are maintained at the Montour Power Station. Continuous readings are recorded on reservoir level and discharges to the stream.

2.4 Evaluation.

a. Availability. Engineering data were provided by PennDER Bureau of Dam Safety, Obstructions and Storm Water Management and the Pennsylvania Power & Light Company. Members of the Pennsylvania Power & Light Company accompanied the inspection team to answer questions on construction, design and operation of the dam.

b. Adequacy. The type and amount of design data and other engineering information is substantial. The information is sufficient to complete a Phase I Report.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The onsite inspection of Lake Chillisquaque was conducted by personnel of L. Robert Kimball and Associates accompanied by members of the engineering staff of Pennsylvania Power and Light Company on May 23, 1979. The inspection consisted of :

1. Visual inspection of the retaining structure, abutments and toe.
2. Examination of the spillway facilities, exposed portions of any outlet works and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.
4. Evaluation of the downstream area hazard potential.

b. Dam. The dam appears to be in good condition. The dam appears to conform closely to the construction drawings. From a brief survey conducted during the inspection, it was noted that the crest of the dam is higher than the design height. It appears that additional material was placed to form an access road over the top of dam. The upstream and downstream slopes were measured at 2.5H:1V and were covered with weathered shale. No vegetation is growing on these slopes with the exception of one small tree near the left abutment of the downstream slope. No erosion or slumping was noted on the downstream slope. At the toe of the dam are several wet areas. These wet areas may be from poor surface drainage or from minor amounts of water exiting from the toe. No flow was noted in any of these areas (See page A-12).

c. Appurtenant Structures. The reservoir level at the time of the inspection was at elevation 594.3. The emergency spillway crest is at elevation 600.0. The concrete weir appeared to be in good condition. The length of the concrete weir at elevation 600 appears to be shorter (750 feet) than the design length (800 feet). The concrete weir then slopes to elevation 605 (107 feet long). The emergency spillway exit channel appeared to be in good condition. The bottom and side slopes of the exit channel are grassed. Near the end of the emergency spillway exit channel, a large amount of stone was placed when a high discharge in 1975 eroded part of the bottom of the discharge channel. This dumped rock probably would not restrict flow significantly.

The condition of the two 36" drainlines was unobserved during the inspection. The concrete control tower appeared to be in good condition. The discharge end of the pipes and the valve house appeared to be in good condition. The valve house is kept locked at all times. Operation of the valves is controlled at the power plant, however, the valves can be operated manually in the valve house.

d. Reservoir Area. The watershed is covered mostly with farmland. The reservoir slopes are gentle and are not susceptible to massive landslides which would affect the storage volume of the reservoir or overtopping of the dam by displacing water.

e. Downstream Channel. The channel downstream of Lake Chillisquaque is wide and gentle. The first structure to be affected by flood flows or failure of the dam would be the visitors center and curators home for the Montour Wildlife Preserve. Several additional homes are located in the flood plain between the dam and the Montour Station.

3.2 Evaluation. In general, the embankment and appurtenant structures appear to be in good condition and well maintained. The wet areas at the toe of the dam should be examined during the normal inspections. The tree should be removed from the embankment.

Note: Considerable precipitation occurred prior to and during a portion of the inspection possibly contributing to the wet areas noted at the toe and also possibly obscuring any small volume seeps or isolated wet areas. Dry weather inspections by the owner are encouraged.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures. The reservoir is maintained at approximately elevation 594.0. Water is pumped from the Susquehanna River to Lake Chillisquaque to be used for emergency cooling water. Procedures to be utilized during flooding are outlined in section 1.2h.

4.2 Maintenance of Dam. No planned maintenance schedule is utilized. Maintenance of the dam is performed by Pennsylvania Power and Light personnel. Maintenance of the dam is considered good.

4.3 Maintenance of Operating Facilities. The valves are operated on an as needed basis. The valves should be operated and lubricated on a regularly scheduled basis. Maintenance of the operating facilities is considered fair.

4.4 Warning System in Effect. There is no warning system in effect to warn downstream residents of large spillway discharges or failure of the dam.

4.5 Evaluation. Maintenance of the dam is considered good. Maintenance of the operating facilities is considered fair. The valves should be operated and lubricated on a regular basis. *There is no warning system in effect to warn downstream residents.*

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. Hydrologic and hydraulic information are contained in a report prepared by Ebasco. This data consists of an inflow hydrograph, spillway rating curves and area-capacity curves. The designer used the PMF (25 inches of rainfall for a 6 hour duration) as the design storm. Based on this amount of precipitation over the drainage area and using a unit triangular hydrograph, the peak inflow to the reservoir was determined to be 24,500 cfs. The total flood volume would be about 6,800 acre-feet. Design calculations indicate the emergency spillway can control this flood.

The designer's calculations appear to be adequate to meet the Corps of Engineers spillway guidelines.

b. Experience Data. The maximum flood to date was during September 1975 when the reservoir level reached elevation 601.6. The peak discharge through the emergency spillway during this flood was estimated at 4500 cfs.

c. Visual Observations. The spillway and spillway discharge channel appeared to be in good condition. The concrete on the spillway weir appears to be in good condition. The rock placed in the spillway exit channel should not retard flow significantly.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, Baltimore District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers, Davis, California, July 1978. The major methodologies or key input data for this program are discussed briefly in Appendix D.

5.2 Evaluation Assumptions. To enable us to complete the hydraulic and hydrologic analysis for this structure, it was necessary to make the following assumptions.

1. The water level in the reservoir prior to flood was at normal pool elevation 594.0.

2. No flow through the 36" pipe was assumed.

5.3 Summary of Overtopping Analysis. Complete summary sheets from the computer output are presented in Appendix D.

Peak inflow - 11,182 cfs
Spillway capacity - 29,022 cfs

a. Spillway Adequacy Rating. The Spillway Design Flood (SDF) for this dam is the PMF. The SDF is based on the hazard and size classification of the dam. Based on the following definition provided by the Corps of Engineers, this spillway is rated as adequate as a result of our hydrologic analysis.

Adequate - For intermediate size dams which pass the PMF.

The spillway and reservoir are capable of controlling the PMF without overtopping the embankment.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. No signs of slumping, erosion or instability were noted during the inspection. The wet area at the toe of the dam should be watched for significant changes.

b. Design and Construction Data. Stability analysis calculated for design of the dam indicated a safety factor of 1.72 for steady seepage conditions with reservoir water level at elevation 600. For rapid drawdown conditions, a safety factor on 1.17 was calculated. See Figure 5 for design assumptions. The stability analyses performed for this structure appear to be adequate.

c. Operating Records. Good operating records are maintained on the reservoir water level. Operating records do not indicate any structural instability.

d. Post-Construction Chnages. There have been no post-construction changes to the dam.

e. Seismic Stability. The dam is located in seismic zone 1. No seismic stability analysis has been performed. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. Because of the low risk of seismic activity and the adequate static analyses, no seismic analysis is necessary.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The dam appears to be in good condition. The visual observations, review of available information, hydrologic calculations and past operational performance indicate that Lake Chillisquaque's spillway is adequate. The spillway is capable of controlling the PMF without overtopping. Adequate stability analyses have been performed for the design of the structure.

b. Adequacy of Information. Sufficient information is available to complete a Phase I Report.

c. Urgency. The recommendations suggested below should be implemented immediately.

d. Necessity for Further Investigation. No further investigations are required at this time.

7.2 Recommendations/Remedial Measures

1. Continue to remove all trees from the embankment.

2. The wet areas at the toe of the embankment should be examined during the routine inspections. Drainage from these areas should be provided and flow monitored when it exists.

3. A formal inspection program should be instituted.

4. A warning system should be instituted to warn downstream residents of large spillway discharges or failure of the dam.

5. Valves should be operated and lubricated on a regularly scheduled basis.

APPENDIX A

CHECKLIST, VISUAL INSPECTION, PHASE I

CHECK LIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Lake Chillisquaque COUNTY Montour STATE Pennsylvania ID# PA-815

TYPE OF DAM Earthfill HAZARD CATEGORY High

DATE(s) INSPECTION May 23, 1979 WEATHER Rainy TEMPERATURE 60°

POOL ELEVATION AT TIME OF INSPECTION 594.3 M.S.L. TAILWATER AT TIME OF INSPECTION None M.S.L.

INSPECTION PERSONNEL:

R. Jeffrey Kimball, L. Robert Kimball and Associates

James T. Hockensmith, L. Robert Kimball and Associates

Kuang-hwei Chuang, L. Robert Kimball and Associates

Don Werley, Pennsylvania Power and Light Company

Andy Spear, Pennsylvania Power and Light Company

James T. Hockensmith RECORDER

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None noted.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Horizontal alignment appears to be good. Vertical alignment - all elevations higher than design height.	
RIPRAP FAILURES	None.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	One tree located on downstream slope near left abutment.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appear to be good.	
ANY NOTICEABLE SEEPAGE	No seepage noted. Several wet areas noted at toe of dam.	
STAFF GAUGE AND RECORDER	Constant readings at Montour Power Plant of reservoir level and discharges.	
DRAINS	None.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	
STAFF GAUGE OR RECORDER	N/A	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Two 36" steel drain lines unobserved during the inspection except at the discharge end which appeared to be good.	
INTAKE STRUCTURE	Intake structure appears to be in good condition.	
OUTLET STRUCTURE	Outlet structure appears to be in good condition.	
OUTLET CHANNEL	Good condition.	
EMERGENCY GATE	Unobserved during the inspection.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Concrete weir in good condition.	
APPROACH CHANNEL	Weathered shale appears to be in good condition.	
DISCHARGE CHANNEL	Open cut with grassed bottom and side slopes. Good condition.	
BRIDGE AND PIERS	None.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

DOWNSTREAM CHANNEL

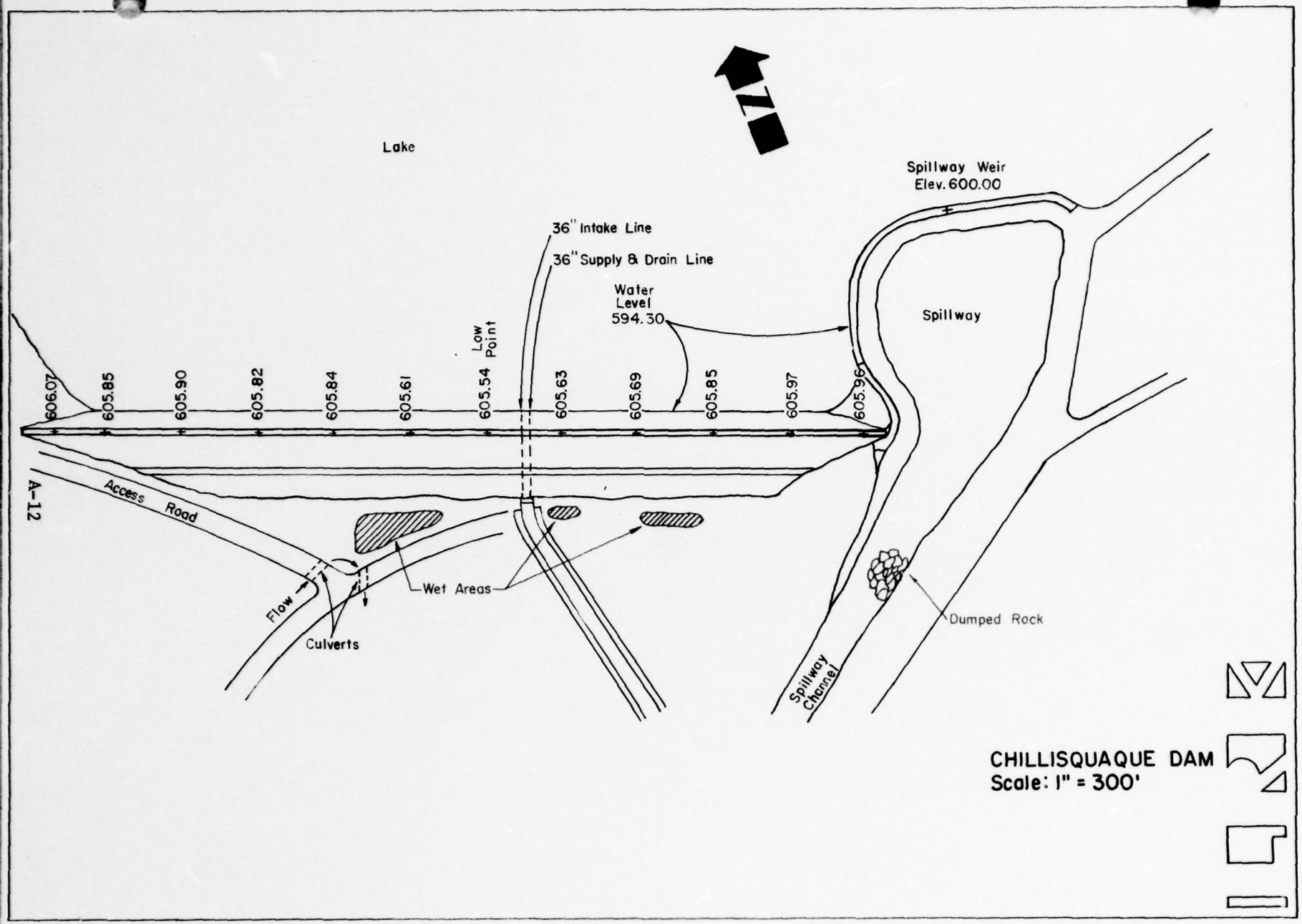
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Very wide and flat. No obstructions noted.	
SLOPES	Stable.	
APPROXIMATE NO. OF HOMES AND POPULATION	Approximately four homes between toe of dam and Montour Station - 16 people. Variable numbers of people are at the visitors center and at the power plant.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gentle, stable.	
SEDIMENTATION	Does not appear to be excessive.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	


Lake
Spillway Weir
Elev. 600.00
36" Intake Line
36" Supply & Drain Line
Water
Level
594.30
Spillway
Low
Point
606.07
605.85
605.90
605.82
605.84
605.61
605.54
605.63
605.69
605.85
605.97
605.96
A-12
Access Road
Flow
Culverts
Wet Areas
Dumped Rock
Spillway
Channel
CHILLISQUAQUE DAM
Scale: 1" = 300'

APPENDIX B

CHECKLIST, ENGINEERING DATA, DESIGN, CONSTRUCTION, OPERATION, PHASE I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Lake Chillisquaque

ID# PA-815

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. quadrangle and construction drawings.
CONSTRUCTION HISTORY	DER files and Pennsylvania Power and Light files.
TYPICAL SECTIONS OF DAM	Construction drawings.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	Construction drawings.
RAINFALL/RESERVOIR RECORDS	Pennsylvania Power and Light Company, Montour Station.

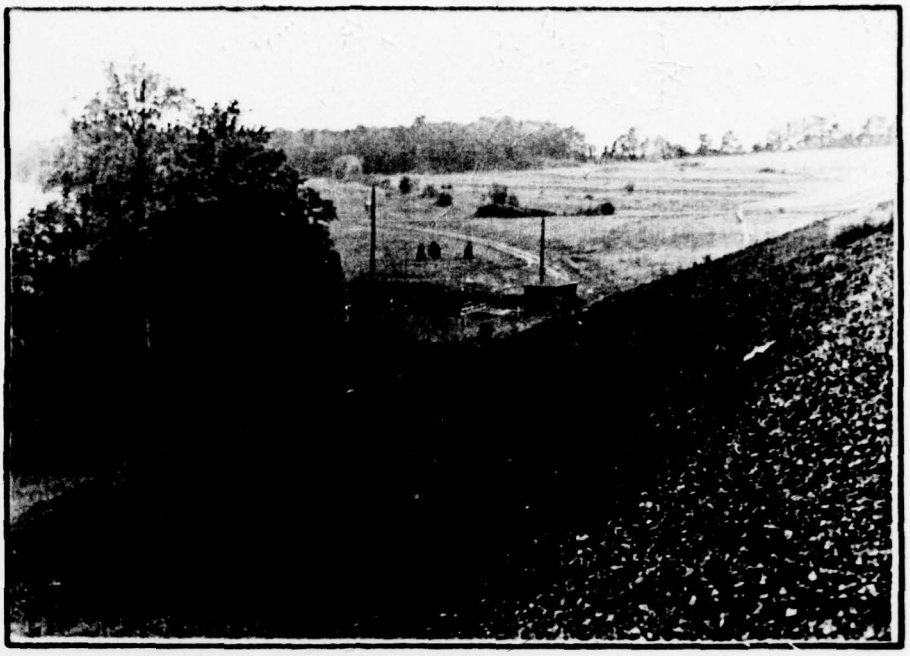
ITEM	REMARKS
DESIGN REPORTS	Ebasco design reports.
GEOLOGY REPORTS	Ebasco reports.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Ebasco reports and construction drawings.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Construction drawings and Pennsylvania Power and Light Company records.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Construction drawings.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	None.
HIGH POOL RECORDS	Pennsylvania Power and Light Company, Montour Station.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None.
MAINTENANCE OPERATION RECORDS	Pennsylvania Power and Light Company, Montour Station.

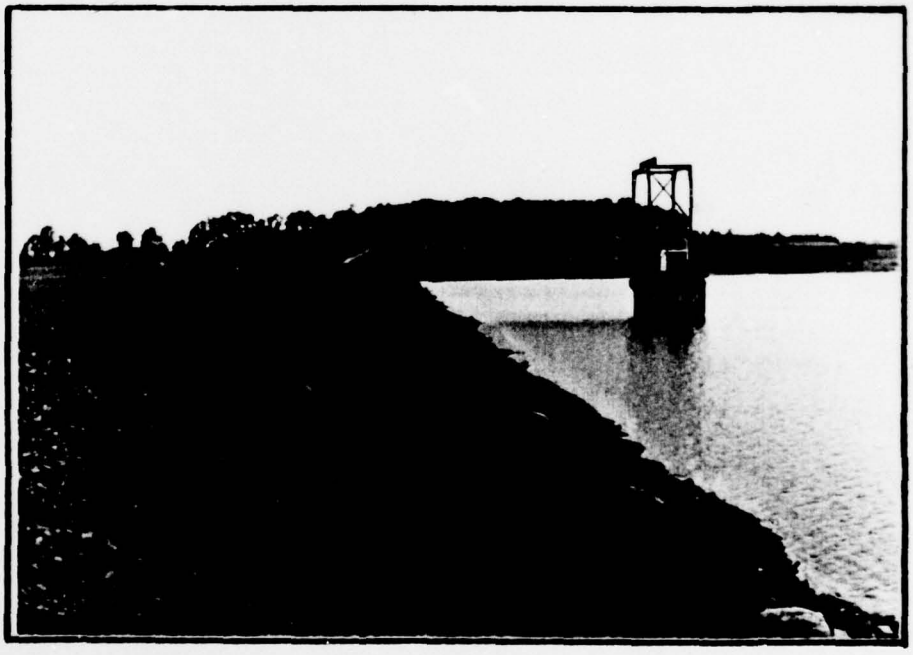
ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	Construction drawings.
OPERATING EQUIPMENT PLANS & DETAILS	Construction drawings.

APPENDIX C

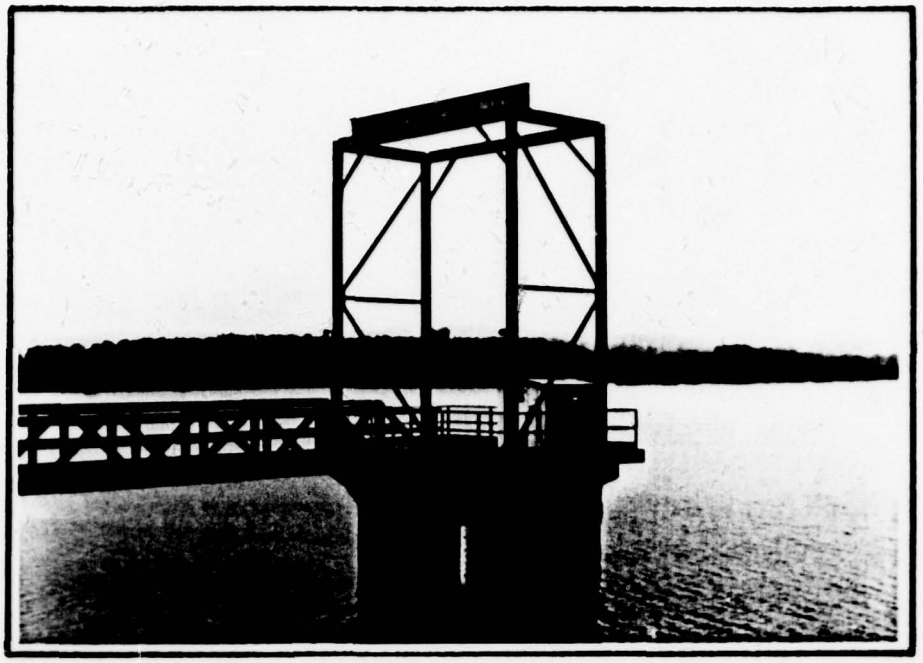
PHOTOGRAPHS



Downstream Slope. Note valve house at toe.

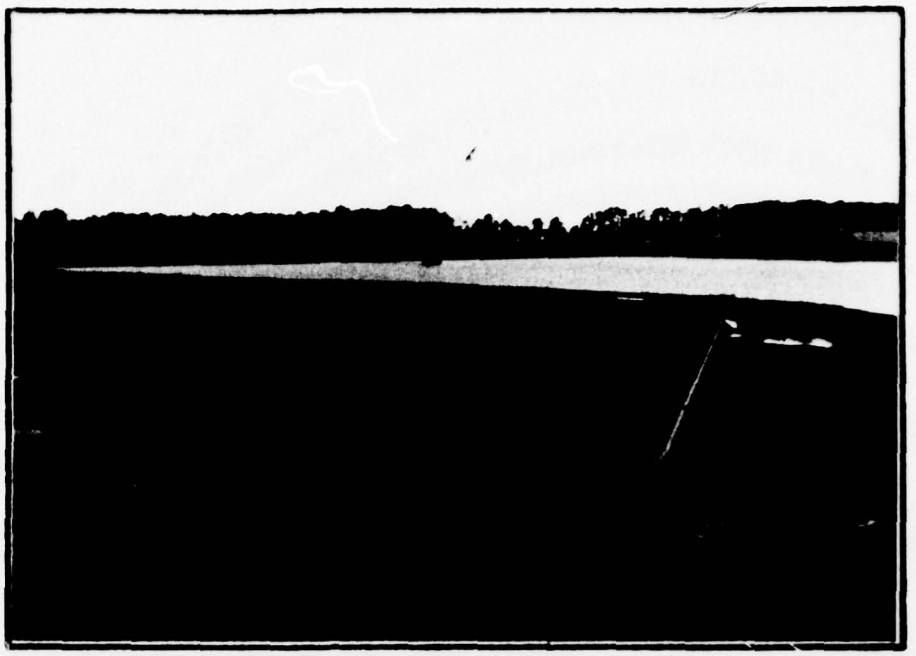


Upstream Slope. Note control tower.



Close-up of control tower.

Immediate downstream exposure.



Spillway weir on left abutment.

Spillway discharge channel.

Wet area at downstream toe.

Residence along stream downstream of dam.

APPENDIX D

HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology. The dam overtopping and breach analyses were accomplished using the systemized computer program HEC-1 (Dam Safety Investigation), September, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. A brief description of the methodology used in the analysis is presented below.

1. Precipitation. The Probable Maximum Precipitation (PMP) is derived and determined from regional charts prepared from past rainfall records including "Hydrometeorological Reports No. 40 prepared by the National Weather Service.

The index rainfall is reduced from 10% to 20% depending on watershed size by utilization of what is termed the HOP Brook adjustment factor. Distribution of the total rainfall is made by the computer program using distribution methods developed by the Corps.

2. Inflow Hydrograph. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for reservoir routing.

The unit hydrograph is developed using the Snyder method. This method requires calculation of several key parameters. The following list gives these parameters their definition and how they were obtained for these analysis.

Parameter	Definition	Where Obtained
C_t	Coefficient representing variations of watershed slope and storage	From Corps of Engineers*
L	Length of main stream channel miles	From U.S.G.S. 7.5 minute topographic
L_{ca}	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic
C_p	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic

*Developed by the Corps of Engineers on a regional basis for Pennsylvania.

3. Routing. Reservoir routing is accomplished by using Modified Plus routing techniques where the flood hydrograph is routed through reservoir storage. Hydraulic capacities of the outlet works, spillways and the crest of the dam are used as outlet controls in the routing.

The hydraulic capacity of the outlet works can either be calculated and input or sufficient dimensions input and the program will calculate an elevation discharge relationship.

Storage in the pool area is defined by an area - elevation relationship from which the computer calculates storage. Surface areas are either planimetered from available mapping or U.S.G.S. 7.5 minute series topographic maps or taken from reasonably accurate design data.

4. Dam Overtopping. Using given percentages of the PMF the computer program will calculate the percentage of the PMF which can be controlled by the reservoir and spillway without the dam overtopping.

5. Dam Breach and Downstream Routing. The computer program is equipped to determine the increase in downstream flooding due to failure of the dam caused by overtopping. This is accomplished by routing both the pre failure peak flow and the peak flow through the breach (calculated by the computer with given input assumptions) at a given point in time and determining the water depth in the downstream channel. Channel cross-sections taken from U.S.G.S. 7.5 minute topographic maps were used in the downstream flood wave routing. Pre and post failure water depths are calculated at locations where cross-sections are input.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME CHILLISQUAQUE DAM
I.D. NUMBER PA. 47-8
SHEET NO. 1 OF 2
BY OTM DATE 6-26-79

CHILLISQUAQUE DAM

DRAINAGE AREA

AREA = 5.6 MI^2 (FROM U.S.G.S. 7.5-MIN. QUAD AND DER FILE)

UNIT HYDROGRAPH PARAMETERS

DAMSITE LOCATED IN ZONE #17, SUSQUEHANNA RIVER BASIN. FROM CORPS OF ENGINEERS, BALTIMORE DISTRICT REGIONAL STUDY.

$C_p = 0.45$, $C_t = 1.13$

$L = 5.0$ MI, $L_{ca} = 1.67$ MI (U.S.G.S. 7.5-MIN. QUAD.)

$t_p = C_t (L \times L_{ca})^{0.3} = 1.13 (5 \times 1.67)^{0.3}$

$t_p = 2.14$ HRS. (SNYDERS LAG (t_p) IN HRS.)

LOSS RATE AND BASE FLOW PARAMETERS

AS RECOMMENDED BY CORPS OF ENGINEERS, BALTIMORE DISTRICT.

STRTL = 1 INCH
CNSTL = 0.05 IN/HR.
STRTQ = 1.5 CFS/MI^2
QRCSN = 0.05 (5% OF PEAK FLOW)
RTIOR = 2.00

PROBABLE MAXIMUM STORM

FROM HR. NO. 40
P.M.P., INDEX RAINFALL = 22.2 (0.99) = 22.0 IN.

$R_6 = 117\%$, $R_{12} = 127\%$, $R_{24} = 136\%$, $R_{48} = 143\%$, $R_{72} = 145\%$

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME CHILLISQUAQUE DAM
I.D. NUMBER PA. 47-8
SHEET NO. 2 OF 2
BY OTM DATE 6-26-79

ELEVATION - CAPACITY RELATIONSHIP

FROM DESIGN DATA, DER FILE.

ELEVATION (FT.)	STORAGE (AC. FT.)
560	0
584	1000
593	2000
594	2250
595	2500
598	3000
600	3350
601	3500
603	4000
605.5	4450

DISCHARGE RATING CURVE

DETERMINED BY HEC-1.

SPILLWAY CREST AT ELEV. 600.0'
LENGTH OF CREST = 750'
COEFFICIENT OF DISCHARGE = 3.0 (BROAD CREST)

OVERTOPPING PARAMETERS

TOP OF DAM AT ELEV. 605.5'
LENGTH OF DAM EXCLUDING SPILLWAY = 2000'
COEFFICIENT OF DISCHARGE = 3.0 (BROAD CREST)

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 5.6 square miles, farmland, gentle slopes

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 594.0 (2200 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 600.0 (3300 acre-feet)

ELEVATION MAXIMUM DESIGN POOL: 604.5

ELEVATION TOP DAM: 605.5

SPILLWAY CREST:

a. Elevation 600
b. Type Uncontrolled with concrete weir
c. Width One foot
d. Length 750 feet
e. Location Spillover Right abutment.
f. Number and Type of Gates None.

OUTLET WORKS:

a. Type Two 36" steel pipes
b. Location Through dam
c. Entrance inverts 552.5
d. Exit inverts 551.4
e. Emergency draindown facilities Sluice gate in control tower

HYDROMETEOROLOGICAL GAUGES:

a. Type Continuous recorder of pool level
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: September, 1975, elevation 601.6, estimated discharge 4500 cfs.

```
*****************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION        JULY 1978
   LAST MODIFICATION  26 FEB 79
*****************************************

A1   ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2   HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CHILLISQUAQUE DAM
A3   RATIOS OF PMF ROUTED THROUGH THE RESERVOIR   PA 67-8
[illegible]
B1    5
J     1      9      1
J1    .1     .2     .3     .4     .5     .6     .7     .8     1
[illegible]
[illegible]   INFLOW TO RESERVOIR
[illegible]
P            22.0   117    127    136    143    145
T                                               160    0.05
W     2.16   0.45
[illegible]
[illegible]
[illegible]   ROUTING RESERVOIR
Y                                 1      1
Y1                                               -594.2
$$    0      1000   2000   2280   2500   3000   3250   3500   4000   4450
[illegible]
[illegible]
[illegible]
K     99
```

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JAN 1978
LAST MODIFICATION 26 FEB 79

RUN DATE 79/08/23
TIME 08:28:03

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CHILLISQUAQUE DAM
RATIOS OF PMF ROUTED THROUGH THE RESERVOIR PG 47-B

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
200	0	15	0	0	0	0	0	0	0

[illegible]	[illegible]	[illegible]	LROPT	TRACE
			0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

[illegible]

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDR	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
	1	1.00	0.00	1.60	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.00	117.00	127.00	136.00	143.00	145.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 2.16 CP= .45 NTAP= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN NUMBER CP AND TP ARE TC= 9.01 AND R=13.61 INTERVALS

UNIT HYDROGRAPH 27 ENDING PERIOD ORDINATES, LAG= 2.16 HOURS, CP= .45 VOL= 1.00

27.	101.	206.	330.	464.	589.	686.	750.	773.	746.
693.	644.	598.	556.	516.	480.	446.	414.	385.	358.
332.	309.	287.	266.	248.	230.	214.	199.	185.	171.
159.	148.	138.	128.	119.	110.	103.	95.	88.	82.
76.	71.	66.	61.	57.	53.	49.	46.	43.	39.
37.	34.	32.	29.	27.	25.	24.	22.	20.	19.
18.	16.	15.	14.	13.	12.	11.	11.	10.	9.
8.	8.	7.	7.	6.	6.	5.			

MO.DA	HRMN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.00	0.00	.00	8.	1.02	12.15	145	.51	.50	.01	731.
1.01	.30	2	.00	0.00	.00	7.	1.02	12.30	146	.51	.50	.01	787.
1.01	.45	3	.00	0.00	.00	7.	1.02	12.45	147	.51	.50	.01	888.
1.01	1.00	4	.00	0.00	.00	6.	1.02	13.00	148	.51	.50	.01	1043.

381.	337.	314.	293.	274.	255.	238.	222.	207.	193.
181.	166.	157.	147.	137.	128.	119.	111.	104.	97.
90.	84.	79.	73.	68.	64.	60.	56.	52.	48.
45.	42.	39.	37.	34.	32.	30.	28.	34.	41.
47.	51.	52.	50.	46.	43.	40.	38.	35.	33.
31.	29.	27.	25.	23.	22.	20.	19.	18.	16.
15.	14.	13.	12.	12.	11.	10.	9.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11182.	8588.	3345.	1149.	331005.
CMS	317.	243.	95.	33.	9373.
INCHES		14.26	22.23	22.91	22.91
MM		362.33	564.94	581.92	581.92
AC-FT		8258.	6435.	6839.	6839.
THOUS CU M		5252.	8184.	8436.	8436.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

RLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
0	0	0	0.000	0.000	0.000	-594.	0

CAPACITY=	0.	1000.	2000.	2250.	2500.	3000.	3250.	3500.	4000.	4450.

ELEVATION= 560. 584. 593. 594. 595. 598. 600. 601. 603. 606.

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
600.0	180.0	3.0	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
608.5	3.0	1.5	2000.

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS							
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8
RATIO 9				.10	.20	.30	.40	.50	.60	.70	.80
1.00											
HYDROGRAPH AT	1	5.60	1	1118.	2236.	3355.	4473.	5591.	6709.	7828.	8946.
11182.				(31.67)(	63.33)(	95.00)(	126.66)(	158.33)(	189.99)(	221.66)(	253.32)(
316.65)											
ROUTED TO	1	5.60	1	0.	1118.	2236.	3355.	4473.	5591.	6709.	7828.
10692.				(0.00)(	31.67)(	63.33)(	95.00)(	126.66)(	158.33)(	189.99)(	221.66)(
302.76)											

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ••••••••••••••••

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	594.30	600.00	605.50
STORAGE	2325.	3350.	4450.
OUTFLOW	0.	0.	29022.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	598.08	0.00	3087.	0.	0.00	0.00	0.00
.20	600.43	0.00	3417.	669.	0.00	47.25	0.00
.30	601.00	0.00	3501.	2267.	0.00	44.25	0.00
.40	601.26	0.00	3540.	3568.	0.00	43.75	0.00
.50	601.47	0.00	3567.	4851.	0.00	43.25	0.00
.60	601.91	0.00	3715.	6084.	0.00	41.00	0.00
.70	602.18	0.00	3796.	7245.	0.00	42.75	0.00
.80	602.41	0.00	3855.	8438.	0.00	42.75	0.00
1.00	602.83	0.00	3957.	10692.	0.00	42.50	0.00

APPENDIX E

DRAWINGS

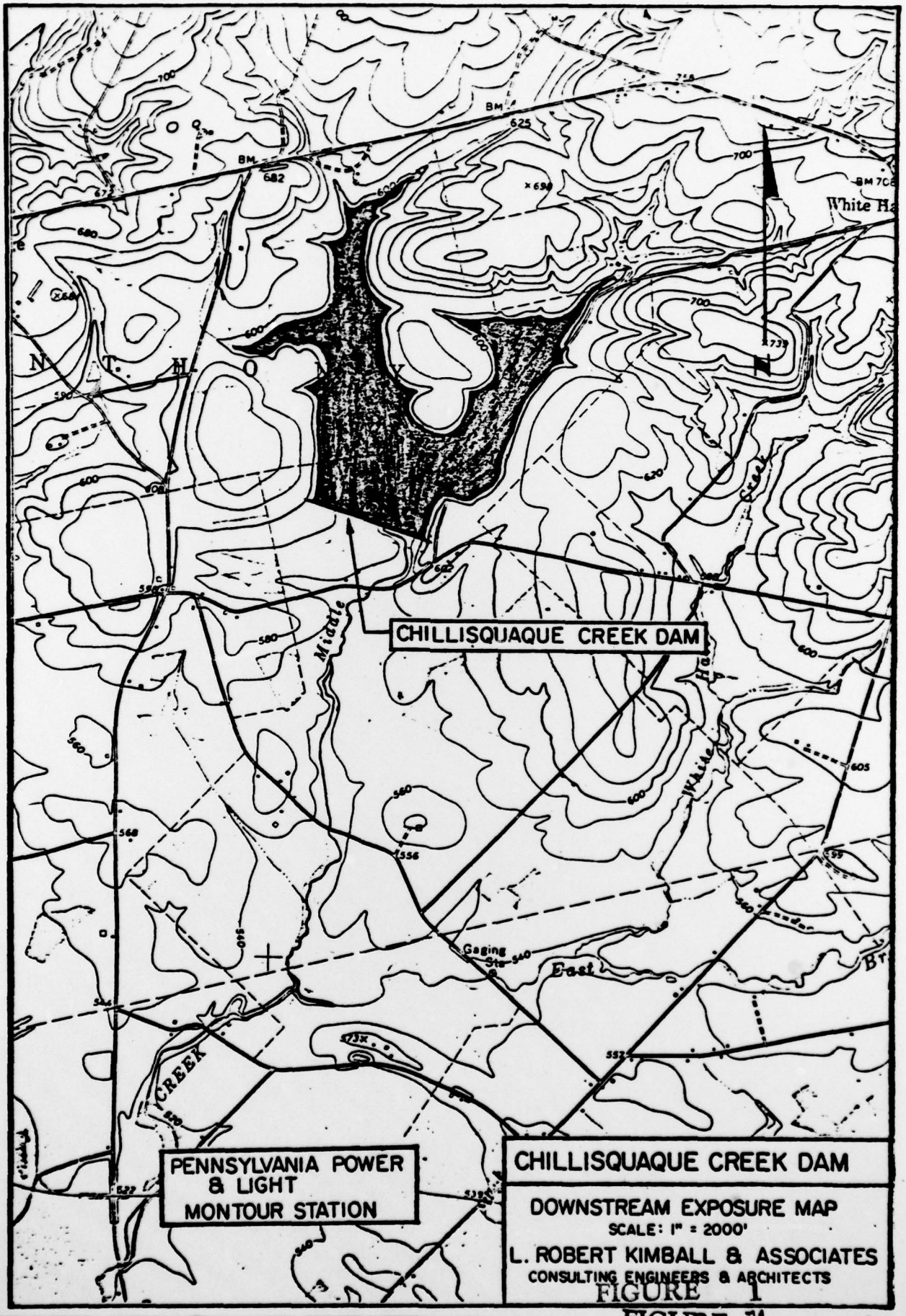
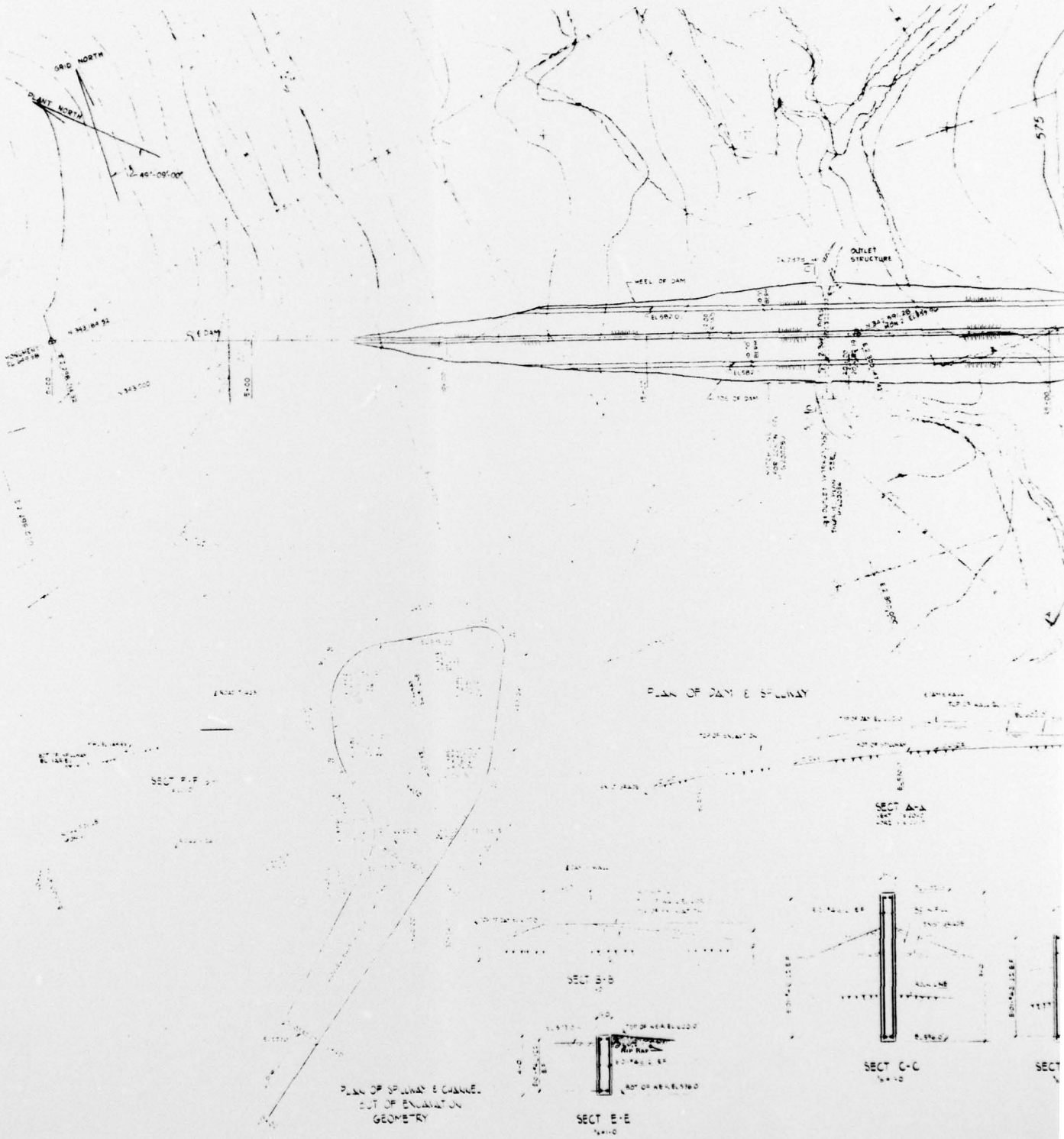
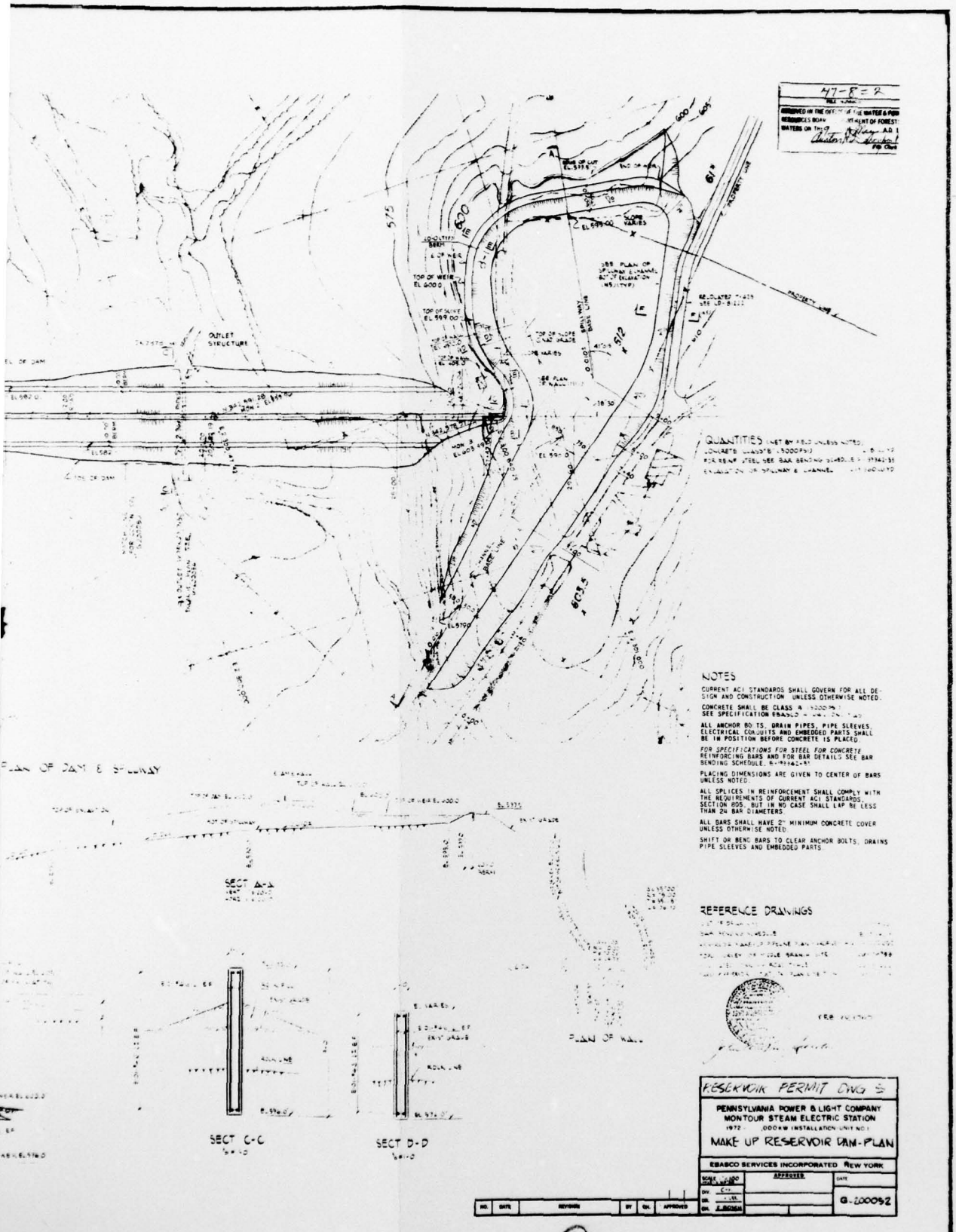

CHILLISQUAQUE CREEK DAM
PENNSYLVANIA POWER & LIGHT MONTOUR STATION
CHILLISQUAQUE CREEK DAM
DOWNSTREAM EXPOSURE MAP
SCALE: 1" = 2000'
L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

FIGURE 1


GRID NORTH
PLANT NORTH
OUTLET STRUCTURE
HEEL OF DAM
PLAN OF DAM & SPILLWAY
SECT A-A
SECT B-B
SECT C-C
SECT E-E
PLAN OF SPILLWAY & CHANNEL CUT OF EXCAVATION GEOMETRY



2

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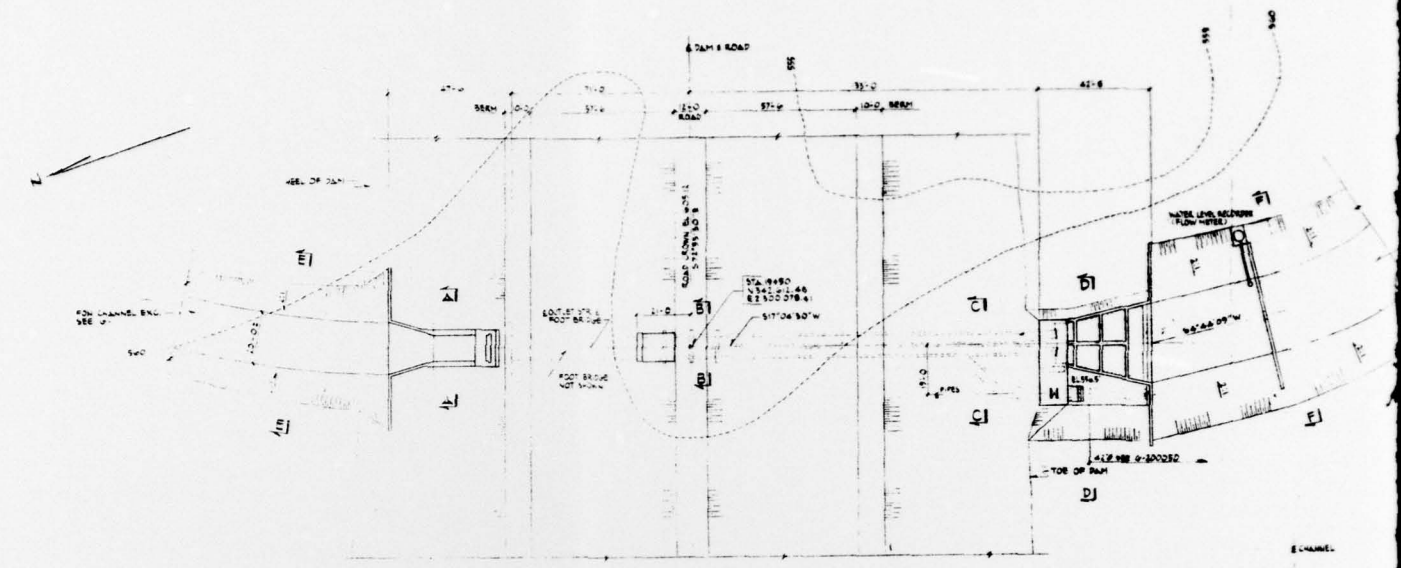
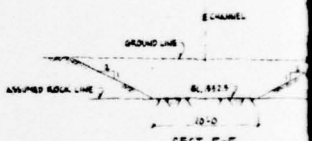
CONSULTING ENGINEERS & ARCHITECTS

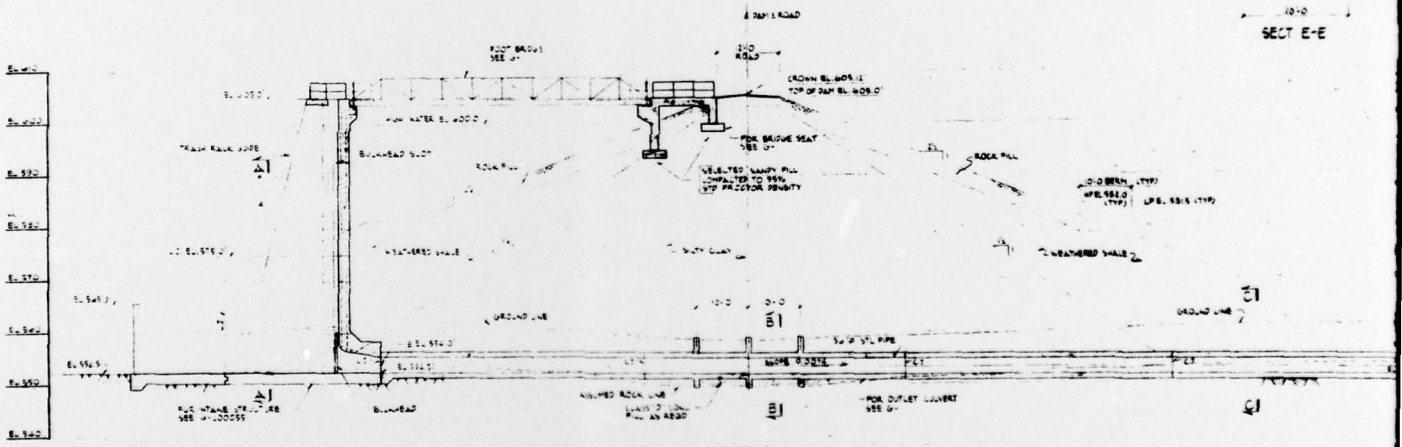
FIGURE 2



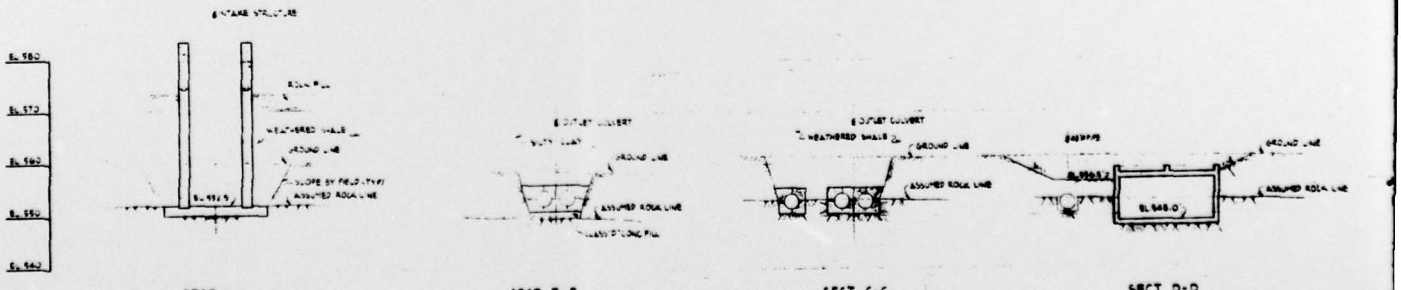
PLAN



SECT E-E



PROFILE



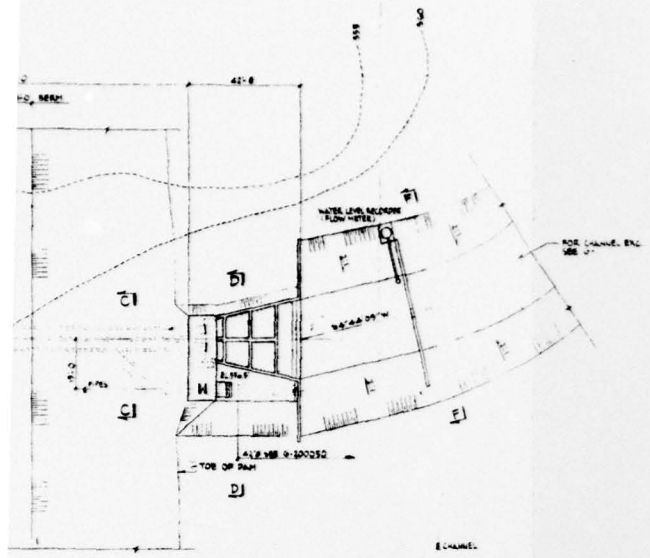
SECT A-A

SECT B-B

SECT C-C

SECT D-D

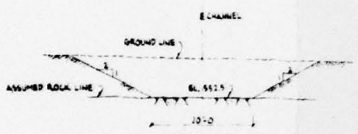
1



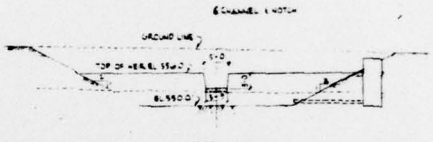
QUANTITIES

NOTES

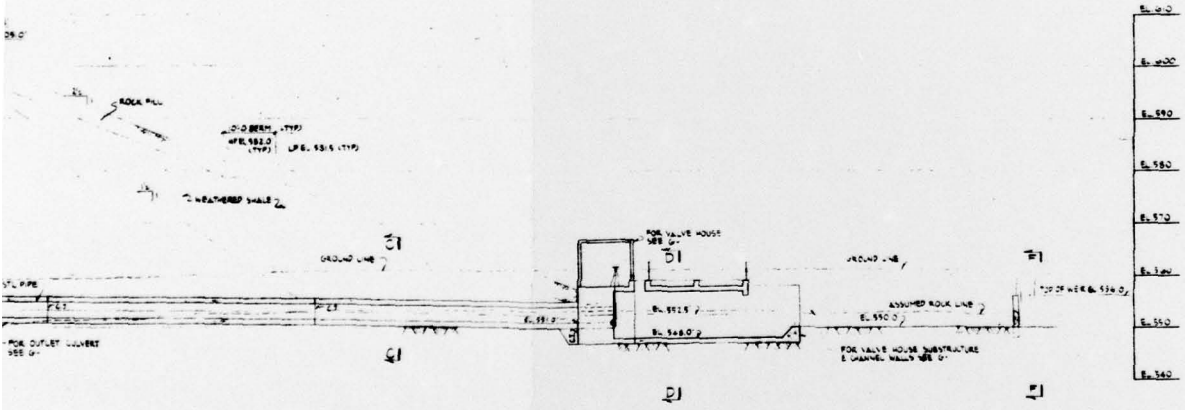
REFERENCE DRAWINGS

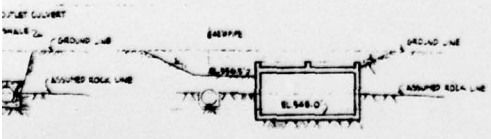


SECT E-E

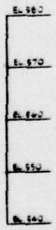


SECT F-F





SECT D-D



FEB 20, 1969

RESERVOIR PERMIT DWG NO.7

PENNSYLVANIA POWER & LIGHT COMPANY
MONTOUR STEAM ELECTRIC STATION
1972 000 KW INSTALLATION-UNIT NO.1
MAKE-UP RESERVOIR
OUTLET STRUCTURE-PLAN & SECTIONS-1165
STEARNS SERVICES INCORPORATED NEW YORK

APPROVED

DATE 3-13-69

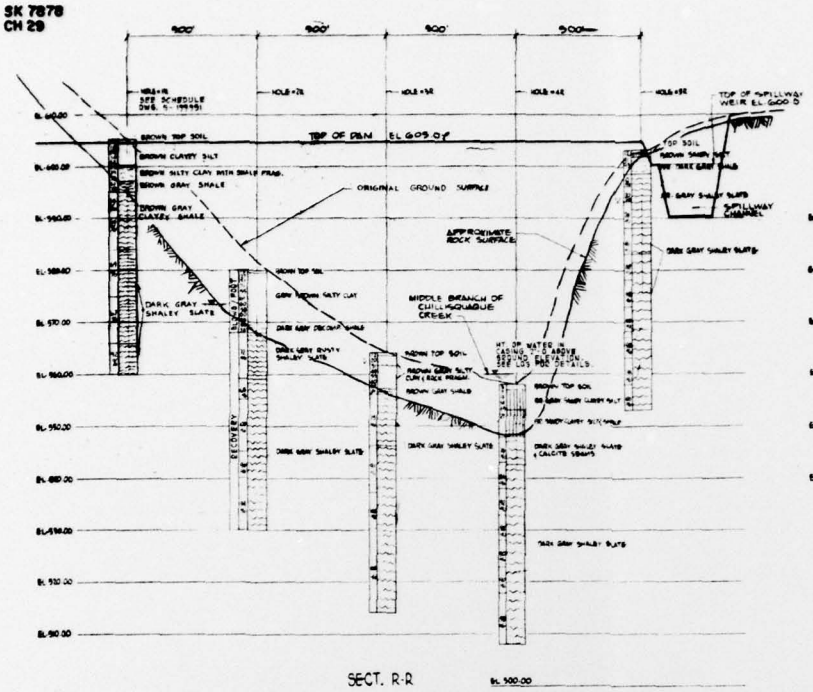
G-200C54

2

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

FIGURE 3

SK 7878
CH 29



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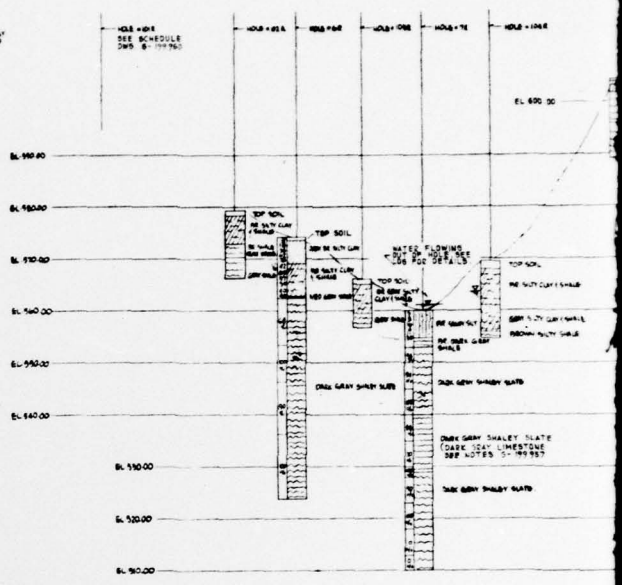

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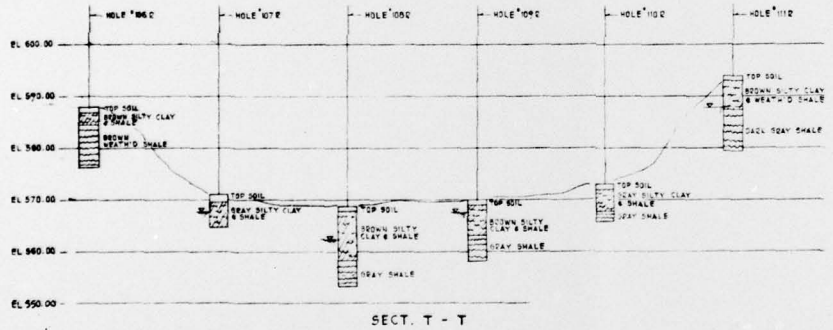

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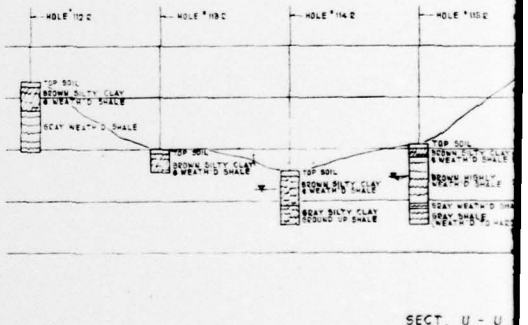

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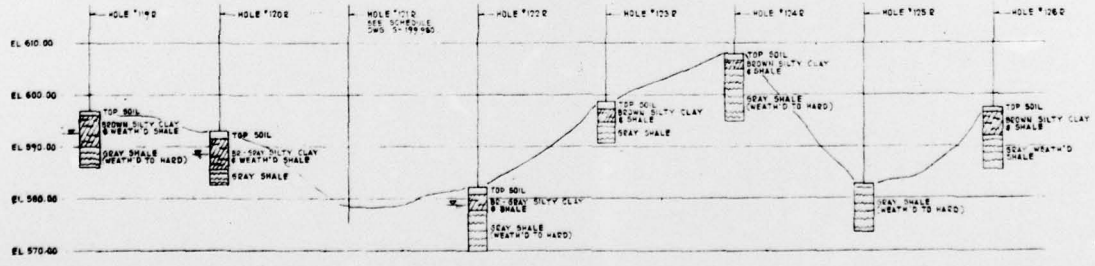

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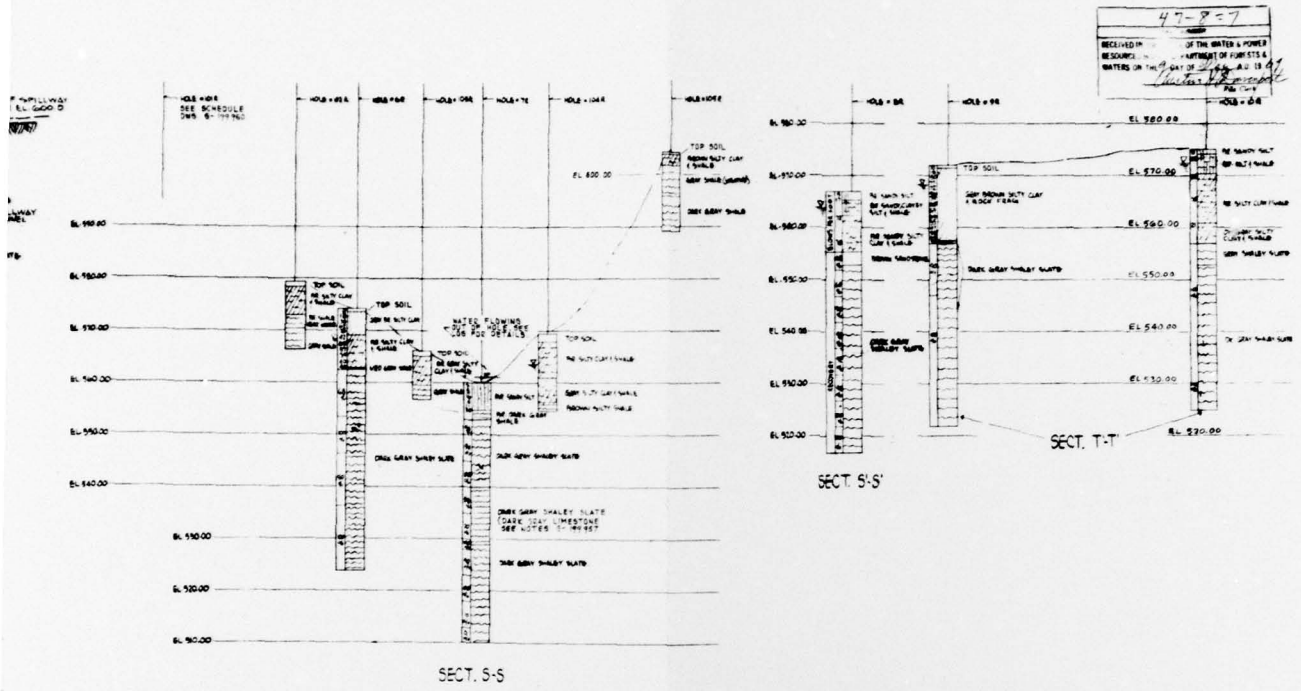
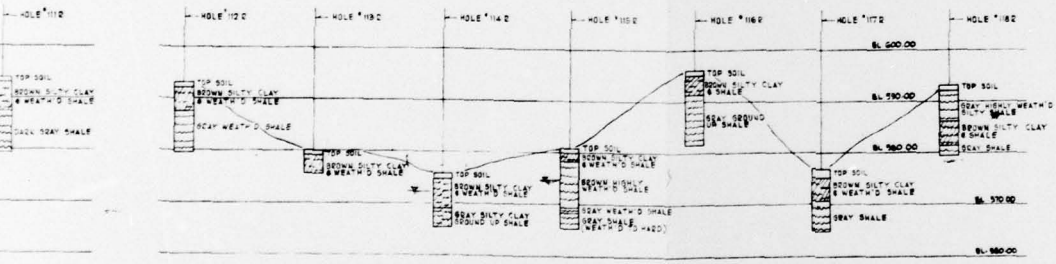
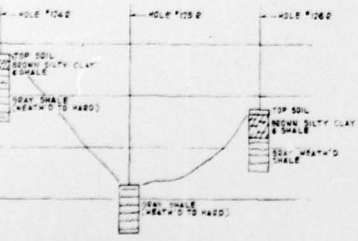






FOR LOCATIONS OF SECTS & BORINGS SEE G-199951

RESERVOIR PERMIT DWG NO. 3

PENNSYLVANIA POWER & LIGHT COMPANY
MONTOUR STEAM ELECTRIC STATION
1972 - 814,000 KW INSTALLATION - UNIT NO. 1

DAM - LONG. SECTION & BORINGS

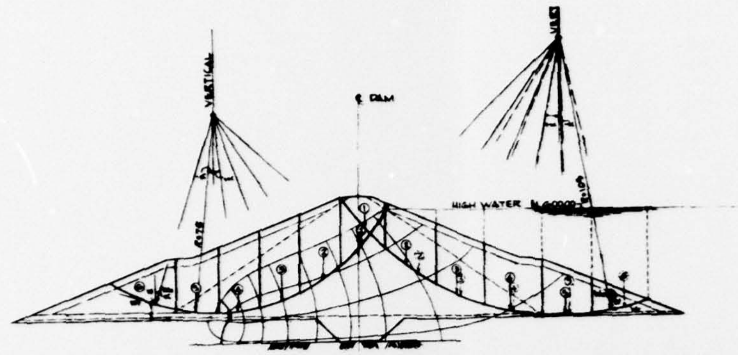
ERASCO SERVICES INCORPORATED

SE 7878
GH 29

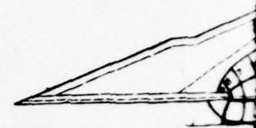
2

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

FIGURE 4



SLIP CIRCLES
1" = 20'



COMPLETE RAPID DRAWDOWN U.S SLOPE   R = 105   FS = 1.17

SLICE NO	GEOMETRIC PROPERTIES: WIDTH FT	AVG HEIGHT FT	AREA SQ FT	α°	SIN α°	COS α°	L FT	PHYS PROPERTIES: φ°	TAN φ°	C KSF	COMPLETE DRAWDOWN: C×L K	γ AVG K/CU FT	W K	Wu K	WT K	U K	Wu-U K	(Wu-U)TAN φ K
1	17.0	10.4	177	47.0	.731	.682	24.0	15	.268	.50	12.0	.114	20.1	18.7	14.7	5.6	8.1	2.2
2	20.0	21.0	420	35.5	.581	.814	25.0	15	.268	.50	12.5	.122	51.4	41.8	29.9	28.1	13.7	3.7
3	20.0	24.2	485	23.5	.399	.917	22.0	15	.268	.50	11.0	.124	60.2	55.2	23.0	29.2	26.0	7.0
4	23.5	22.6	532	10.5	.182	.983	24.0	15	.268	.50	12.0	.128	68.0	66.9	12.4	31.1	35.8	9.6
5	20.0	18.8	375	-1.0	-.017	.999	—	25	.466	—	—	.127	47.6	47.6	-.8	19.6	28.0	13.0
6	23.0	7.3	167	-10.5	-.182	.983	—	25	.466	—	—	.124	20.7	20.3	-3.8	6.8	13.5	6.3
											Σ=47.5				Σ=76.4			Σ=41.8

$FS = \frac{\Sigma(W_u - U)\tan\phi + \Sigma(C \times L)}{\Sigma W_T} = \frac{41.8 + 47.5}{76.4} = 1.17$

STEADY SEEPAGE D.S. SLOPE   R = 75'

SLICE NO	GEOMETRIC PROPERTIES: WIDTH FT	AVG HEIGHT FT	AREA SQ FT	α°	SIN α°	COS α°	L FT	PHYS PROPERTIES: φ°	TAN φ°	C KSF	C×L K	γ AVG K/CU FT	W K	Wu K	WT K
1	19.5	16.1	275	49.0	.755	.656	28.0	15	.268	.50	14.2	.118	32.5	21.4	24.6
2	16.0	29.8	476	36.0	.559	.809	20.0	15	.268	.50	10.0	.117	55.5	46.0	31.0
3	16.0	31.8	508	20.0	.342	.940	17.0	15	.268	.50	[illegible]	.118	60.2	56.6	20.6
4	16.0	29.5	472	7.0	.122	.992	16.0	15	.268	.50	[illegible]	.114	53.7	53.3	6.6
5	17.0	24.3	413	-5.0	-.087	.996	17.0	15	.268	.50	8.5	.117	48.2	48.1	-4.2
6	27.5	11.0	302	-19.0	-.326	.946	—	25	.466	—	—	.120	36.3	34.4	-11.8
											Σ=49.2				Σ=66.8

$FS = \frac{\Sigma(W_u - U)\tan\phi + \Sigma(C \times L)}{\Sigma W_T} = \frac{65.4 + 49.2}{66.8} = 1.72$

FULL POOL US SLOPE   R = 105   FS = 3.18

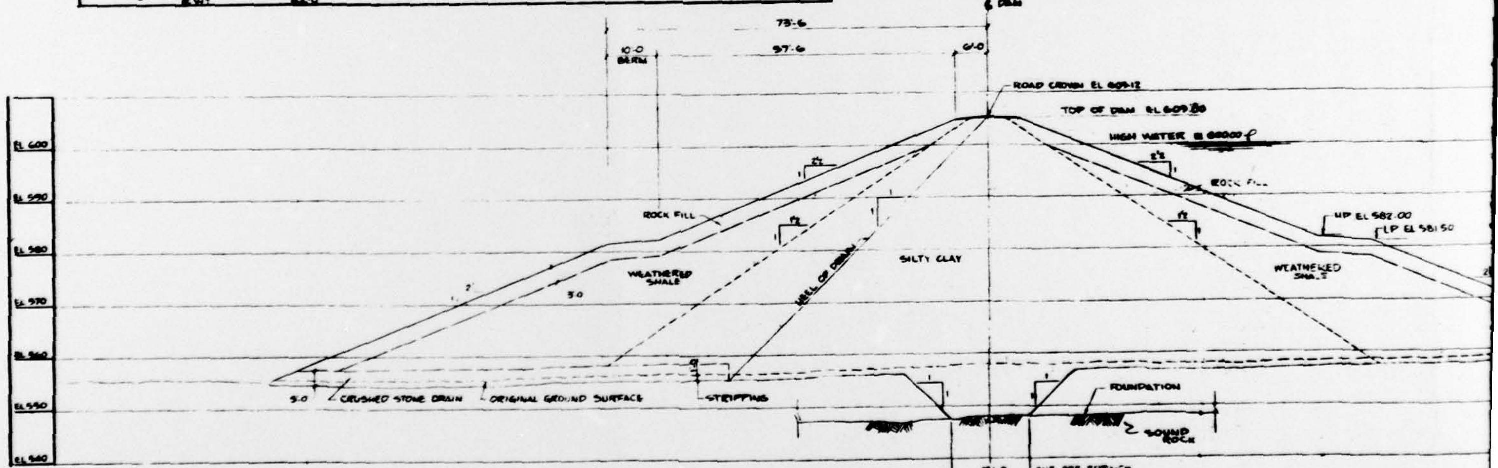
* VALUES FROM TABLE ABOVE

SLICE NO	AREA* SQ FT	α°*	SIN α*	COS α*	L FT*	φ°*	TAN φ*	C KSF*	SOIL: C·L KSF	γ AVG K/CU FT	W	Wu	WT	WATER: α°	SIN α	COS α	W"	W"u	W"T	SOIL + WATER: W'T	W'u	W'u TAN φ
1	177	47.0	.731	.682	24.0	15	.268	.50	12.0	.092	16.2	11.0	11.8	—	—	—	—	—	—	11.8	11.0	2.9
2	420	35.5	.581	.814	25.0	15	.268	.50	12.5	.063	26.5	21.5	15.4	32.0	.530	.848	1.9	1.6	1.0	16.4	23.1	6.2
3	485	23.5	.399	.917	22.0	15	.268	.50	11.0	.064	31.3	28.7	12.5	22.0	.375	.927	11.2	10.4	4.2	16.7	39.1	10.5
4	532	10.5	.182	.983	24.0	15	.268	.50	12.0	.067	35.6	35.0	6.5	10.0	.174	.985	25.3	24.9	4.4	10.9	59.9	16.0
5	375	-1.0	-.017	.999	—	25	.466	—	—	.068	25.6	25.6	-0.4	-2.0	-.035	.999	28.7	28.7	-1.0	-1.4	54.3	25.3
6	167	-10.5	-.182	.983	—	25	.466	—	—	.064	10.7	10.5	-1.9	-13.5	-.233	.972	45.1	43.9	-10.5	-12.6	54.4	25.4
									Σ=47.5											Σ=42.0		Σ=86.3

$FS = \frac{\Sigma W'_u \tan\phi + \Sigma(C \cdot L)}{\Sigma W'_T} = \frac{86.3 + 47.5}{42.0} = 3.18$

SOIL PROPERTIES

TYPE OF SOIL	DRY UNIT WEIGHT γd (LBS/CU FT)	MOIST UNIT WEIGHT γm (LBS/CU FT)	SATURATED UNIT WEIGHT γs (LBS/CU FT)	SUBMERGED UNIT WEIGHT γs' (LBS/CU FT)	ANGLE OF INTERNAL FRICTION φ°
COMPACTED SILTY CLAY	100	110	125	63	15
COMPACTED WEATHERED SHALE	110	[illegible]	132	70	25
ROCK FILL	100	—	120	58	—



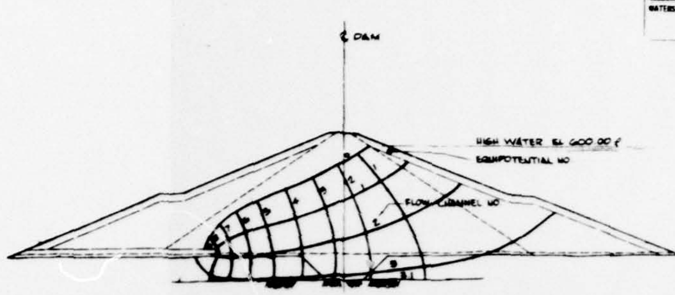
SECTION C-C (6200052, DU)
MAXIMUM SECTION
1" = 20'

1

47-8=3

FILE NUMBER

RECEIVED IN THE OFFICE OF THE WATER & PO[illegible] RESOURCES BOA[illegible] [illegible]MENT OF FORES[illegible] WATERS ON THE [illegible] A.D.



FLOW NET
1"=20'

PERMEABILITY SILTY CLAY + WEATHERED SHALE = 10^{-4} FT/MIN
FLOW THROUGH DAM, MAXIMUM SECTION

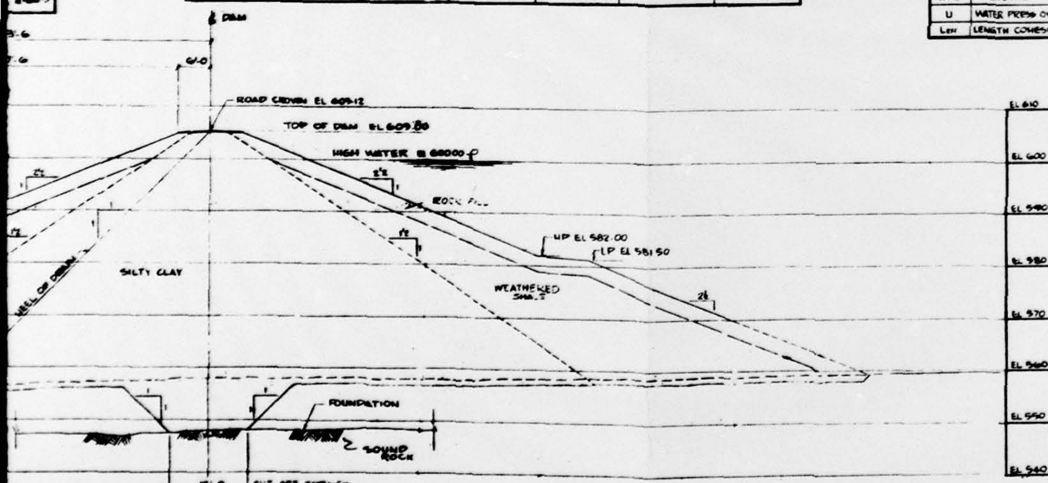
$Q = kh(^{n_f}/_{n_d})$
$= 10^{-4}$ FT/MIN (52)($^{3}/_{9}$)
$Q = 17.9 \times 10^{-4}$ FT³/MIN/FOOT ≈ 5 GPD/FOOT

STEADY SEEPAGE D.S. SLOPE R=75' FS=1.72																		
SLICE NO.	GEOMETRIC PROPERTIES							PHYS. PROPERTIES										
	WIDTH FT	AVG HEIGHT FT	AREA SQ FT	α°	SIN α°	COS α°	L c/φ FT	φ°	TAN φ°	C K/SF	C·L c/φ K	γ AVG K/CU FT	W K	Wn K	Wt K	U K	Wn-U K	(Wn-U)TAN φ
1	19.5	14.1	275	49.0	.755	.656	28.0	19	.268	.50	14.2	.118	32.5	21.6	24.6	8.4	13.0	3.5
2	16.0	29.8	476	34.0	.559	.829	20.0	15	.268	.50	10.0	.117	55.5	46.0	31.0	14.0	32.0	8.6
3	18.0	31.8	[illegible]	20.0	.342	.940	17.0	15	.268	.50	8.6	.118	60.2	56.6	20.6	13.0	43.6	11.8
4	16.0	28.5	472	7.0	.122	.992	16.0	15	.268	.50	8.0	.114	53.7	53.3	6.6	6.2	47.1	12.6
5	17.0	24.3	413	-5.0	-.087	.996	17.0	15	.268	.50	8.5	.117	48.2	48.1	-4.2	—	48.1	12.9
6	27.5	11.0	302	-19.0	-.326	.946	—	25	.466	—	—	.120	36.3	34.4	-11.8	—	34.4	16.0
$FS = \frac{\Sigma(W_n-U)\tan\phi + \Sigma(C \cdot L)}{\Sigma W_T} = \frac{65.4 + 49.2}{66.6} = 1.72$											Σ=49.2				Σ=66.6			Σ=65.4

SOIL PROPERTIES						
TYPE OF SOIL	DRY UNIT WEIGHT γ_D (LBS/CU FT)	MOIST UNIT WEIGHT γ_M (LBS/CU FT)	SATURATED UNIT WEIGHT γ_S (LBS/CU FT)	SUBMERGED UNIT WEIGHT γ_S' (LBS/CU FT)	ANGLE OF INTERNAL FRICTION φ°	COHESION C (LBS/SQ FT)
COMPACTED SILTY CLAY	100	110	125	63	15	500
COMPACTED WEATHERED SHALE	110	125	132	70	25	—
ROCK FILL	100	—	120	58	—	—

SYMBOLS	
γ	UNIT WEIGHT
W	WEIGHT OF SLICE
Wn	NORMAL COMPONANT OF W
WT	TANGENTIAL COMPONENT OF W
W''	WEIGHT OF WATER ON THE SLICE
W'	TOTAL COMPONENT
US	UPSTREAM
DS	DOWNSTREAM
AVG	AVERAGE
U	WATER PRESS ON SLICE BASE
Lc/φ	LENGTH COHESION ACTS ON

TER	
NG TAN φ	
2.9	
6.2	
10.5	
18.0	
25.3	
25.4	
Σ=66.5	



SECTION C-C (8200052, DH)
MAXIMUM SECTION
1"=20'

FEB 20, 1969

MAR 1 1969

RESERVOIR PERMIT [illegible]

PENNSYLVANIA POWER & LIGHT COMPANY
MONTOUR STEAM ELECTRIC STATION
1972 - 814,000 KW INSTALLATION - UNIT NO. 1
MAKE-UP RESERVOIR DAM
STABILITY ANALYSIS

EBASCO SERVICES INCORPORATED NEW YORK

SCALE AS NOTED | APPROVED | DATE MAR 1 3 1969

G-SK 7878
CH-41

2

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

FIGURE 5

APPENDIX F

GEOLOGY

General Geology.

Lake Chillisquaque lies in the Valley and Ridge Physiographic Province of Fennemann (1938). This region in Eastern Pennsylvania is characterized by numerous synclinal and anticlinal features. Structurally, the dam lies near the axis of a large plunging anticlinal feature which plunges to the northeast. Major faulting is not noted in the area. The dam is underlain by Middle Ordovician aged sediments of the Mahantango Formation. This formation extends for a thickness of 1000 to 1500 feet. It is a brown to olive shale with interbedded sandstone. The upper members are highly fossiliferous.

GEOLOGIC MAP OF LAKE CHILLISQUAQUE DAM AREA

Scale: 1:250,000